

Agricultural Research Institute, Pusa

INSECTICIDES

Mixtures and Recipes for Use against Insects
in the Field, the Orchard, the Garden
and the House

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PREFACE.

WE receive a considerable number of enquiries from residents in India regarding methods of checking insect pests. These enquiries show what class of thing is wanted, and we have here tried to meet this demand by a short simple description of insecticides made from materials available in India. Insecticides have only a definite limited application; in the field they are usually replaced by other methods, but in the garden, orchard and house, they have a very wide application, little employed in India at present.

H. M. L.

Insecticides—Mixtures and Recipes for Use against Insects in the Field, the Orchard, the Garden and the House.

Insecticides.

FOR more than six years, the use of insecticides as a means of combating destructive insects has been tried, practised and advocated in India and we propose to condense in a few pages the experience we have gained and the methods which we believe are practicable and useful. Some years ago, the use of insecticides was practically unknown in India; a small amount of Paris Green was sold, and there was a small use of such insecticides as Kerosene Emulsion, usually imperfectly prepared. In 1903, the use of Lead Arseniate was introduced to replace Paris Green, London Purple, etc.; arrangements were made for its manufacture and sale and it took its place as a standard method. At the same time, Crude Oil Emulsion was invented and introduced and it was placed on the market and has been sold extensively. These represented the latest advances in entomological practice and both have justified their introduction.

At the same time, there are disadvantages, peculiar to India, in the use of any arsenical poison and efforts have been made to replace Lead Arseniate. There has also been a continuous demand for simple household and garden insecticides, and, while the use of insecticides on a large scale in the field must remain impracticable, there has been a growth in the use of insecticides on special crops such as tea and coffee, on fruit trees, and on the valuable market garden crops which are grown so extensively in India. Such insecticides are also valuable in ordinary gardens and there are some which are useful in Indian houses. The insecticides recommended here are the result of constant testing and experiment:

we have tested many "patent" insecticides sent for trial or put on the market at different times; not one of these is equal to the simple preparations here described and we have yet to find any reliable "patent" insecticide whose price and efficacy bring it within the range of the ordinary ones we use and recommend; some are extremely good but their price is exorbitant; some are cheap and bad; but we are not aware of any insecticide now in the market which combines efficacy with a moderate price nor is it likely that any insecticide, unless made in India of simple materials, can possibly be sold at a reasonable price; had we found such a preparation, this work would have been unnecessary, as it is not our business to place insecticides on the market and render them available; under the circumstances we have made arrangements to render available the preparations we use and recommend, as it is useless advising insecticides not ordinarily obtainable. This difficulty does not apply to spraying machines: there are many manufactured in America which are excellent; some of these are available in India, and we have introduced some of these which are widely used: the types we recommend are reliable and can be purchased in India; we endeavour to test all makes that are sold here and we recommend none that are not first-rate.

The special insecticides and methods required for tea and coffee spraying are not here dealt with as these have been dealt with elsewhere: the following pages contain only general methods applicable to crops, fruit trees, vegetables, ornamental plants, etc., as well as in houses and on domestic animals.

I. Insecticides on Field Crops.

As a general rule, insecticides cannot, for many reasons, be applied to field crops in India. The exceptions are in the case of crops grown by planters and zamindars familiar with the methods and able to purchase the appliances, of specially valuable crops upon which the necessary expenditure is profitable, and of crops grown upon experimental farms where it is imperative that the results of experiment shall not be lost on account of insect-attack, even if a considerable amount of expenditure must be incurred.

Speaking generally, there are two classes of insects against which insecticides must be used; these are first, caterpillars, grasshoppers, beetles and other biting insects, which by eating the leaves and buds destroy the plant, and secondly, bugs, scale insects, mealy bugs, and the like, which by sucking out the sap of leaves or shoots weaken and kill the plant.

Against the first, we use a "Stomach Poison," *i.e.*, one that acts through the stomach and is applied to the part of the plant to be eaten in such a way that the insect in feeding takes it into its stomach. Against the second, we must use something different, as an insect that sucks sap does not absorb a solid insecticide applied to the outside of a plant; we use accordingly an insecticide which we apply to the insect itself, which acts by contact with its skin and which is accordingly called a "Contact Poison."

Contact poisons of course act on all insects, however they feed, but to kill large caterpillars, beetles, or grasshoppers, we require such strong contact poisons that, as a rule, it is cheaper and better to apply to the plant a stomach poison; in rare cases we use a contact poison for biting insects, as a rule only if they are small.

We can again use two classes of stomach poisons, those which are actual poisons, and those which are deterrents, the former absolutely killing the insect, the latter only making the plant unpleasant to it and preventing it from feeding. Speaking generally, the former are poisonous also to cattle and human beings; if they are really violent poisons, their use except in competent hands is undesirable, but the latter are less efficacious and the difficulty is to combine the two to get a sufficiently poisonous but still not dangerous compound. Lead Arseniate, Paris Green and the like represent the most poisonous compounds, which are extremely effective as poisons and which in competent hands need not injure cattle or human beings; but, for India, any arsenical poison is undesirable and we have for the last four years been seeking a substitute. An insecticide, besides being poisonous, must have other qualities; it must be insoluble in water, not injurious to the plant, not decomposable by atmospheric influences, readily obtained in a fine state of division and cheap. All

these qualities are united with a moderate degree of poisonous

Lead Chromate.

effect in Lead Chromate, a substance we have exhaustively tested and which proved to have the best qualities of all the substances tested. It is obtainable as an insoluble yellow paste, which is readily sprayed on, which remains unaltered by rain or weather for a considerable time, and which is easily seen upon the plant; the paste is also very easily prepared direct in the spraying machine. Lead Chromate is the perfect substitute for arsenical poisons; it may be used as strong as one pound to sixteen gallons of water without injury to the plant but is best used at one pound to thirty to sixty gallons. Lead Arseniate may be used in the same manner and is the standard preparation that has been used in the past. In using Lead Chromate one may use the paste, taking $1\frac{1}{2}$ oz. paste to yield 1 oz. of Lead Chromate, one may use the dried paste, rubbing it up in water, or one may make the compound by dissolving separately 1 oz. of Potassium bichromate and 2 oz. of Lead acetate (or lead nitrate) and mixing the two solutions, when 2 oz. of lead chromate will be precipitated as a flocculent yellow mass. As a rule, it is best to buy the paste and use that.

To apply a stomach poison, the proper quantity is put into the

Application.

spraying machine filled with water and the liquid is well churned up to mix the insecticide properly; the plants are then at once sprayed, a fine spray being directed over the leaves, buds, etc., so as just to wet evenly and deposit the poison on the whole surface. If the plant is one whose leaves do not "wet" easily, a little rosin compound stock solution should be added to the spraying mixture.

In some cases, these poisons can be applied in the dry state as

Dry Poisons.

a very fine powder, dusted on pure or mixed with lime or dust. They may be dusted on through cloth or put on with a proper powder-bellows or powder-spraying machine. In rare cases, as when weevils are attacking young maize or sorghum, this method is useful. In place of these almost any dry metallic paint may be used; such paints as lemon chrome, red lead, white lead, oxide of iron, yellow ochre, red ochre, burnt sienna, burnt umber, Saxon Green, can be bought

in a very finely divided dry state, suitable for dusting on and are effective deterrents in such cases. This method is very effective on crops which cannot be sprayed and is the only effective way as a rule of applying any poison to young crops in the field.

An extremely good deterrent is the fungicide Bordeaux Mixture; as this is used as a fungicide in India, we give a formula for its preparation; it is not difficult to make and is easily applied with a sprayer. Care must be taken to see that it is thoroughly strained when poured into the machine.

Contact Poisons.

Where a crop is attacked by any small sucking insects, especially those which are found fixed on the leaves or shoots in colonies, a fine spray of a contact poison must be applied to them. Contact poisons contain, as effective ingredients, soap, thick-oil, rosin or some other sticky material, or kerosene, phenyl or some other irritant material. The variety of contact poisons is immense but there are really only two points to consider; does one want a soap, *i.e.*, an alkaline liquid which dissolves wax and "wets," or a pure oil which kills directly without the intervention of a solvent alkali? The most "wetting" insecticide known to us which is otherwise suitable is rosin compound; the best oily insecticide is Crude Oil Emulsion; we consider these two, alone or separate, meet all ordinary demands, while either can be replaced by *Vermisapon* which combines the virtues of both types.

Rosin Compound is the easiest insecticide to make and apply generally and is applicable to all sucking insects except the very mealy ones. It may be made from rosin and soda as required. Crude oil emulsion

Rosin Compound.

Crude Oil Emulsion.

is an emulsion of twenty per cent. of soft (fish-oil) soap with eighty per cent. of crude mineral oil (containing kerosene). It is effective against all sucking insects except in cases where these are protected by hairs or a scale and do not get wetted. We use it as a standard contact poison and it is sold ready for mixing with water. Kerosene emulsion is an inferior substitute which however can be made locally as required.

Vermisapon.

A contact poison has been lately discovered and put on the market in the form of *Vermisapon*. It is made in accordance with our suggestions and it can be used in place of either of the above.

In applying contact poisons, one must direct a spray either to the insects themselves, if they can be seen, or to the part of the plant affected, *e.g.*, the buds, so as to kill all the insects that are there.

For Fruit Trees.

In fruit cultivation, one requires contact poisons more often than stomach poisons but both should be at hand. Spraying the foliage of fruit trees with Lead Chromate checks caterpillar attack, and prevents that stripping of the leaves by weevils which is so common in the rains. One can with perfect safety put on Lead Chromate until every leaf looks yellow and this is the best safeguard.

Far more required are contact poisons, against mealy bugs, scale insects, aphides and the like. The best insecticide for general use is either *vermisapon* or a mixture of weak rosin compound (half a pint of stock solution to four gallons of water) into which half a pint of Crude Oil Emulsion has been mixed. But either Crude Oil Emulsion or Rosin Compound may be used separately. For the little hoppers which do so much damage to mango

Mango Hoppers.

in the blossoming season, nothing but prompt spraying with strong rosin compound is effective and this spraying must be done early; it is useless to do it when the blossom is all open and as a rule unless one is expecting and ready for the attack it is too late to do any good. For fruit trees, of course, one must have a good sprayer, a powerful one on wheels with which to reach the whole of an ordinary mango tree. One finds often that these hoppers cluster, not on the leaves, but on the lower side of the big branches and on the trunk; passing one's hand along the bark one feels them jump off; if this is found, the branches and trunk must be sprayed; this is often best done in October if the bugs have been breeding in September, as they sometimes do.

II. Insecticides in the Garden.

As in the case of field crops, we find stomach poisons, deterrents and contact poisons useful in the garden.

Lead Chromate.

For young plants, for all but perfectly mature vegetables such as cabbages and lettuce, Lead Chromate is the best application; if there is difficulty in "wetting" the leaves, a little rosin compound should be added to the spraying mixture.

In some cases, as for instance, for well-formed cabbages or lettuce which will soon be cut, it is better

Naphthalin Emulsion.

to use some insecticide, which is entirely harmless or which evaporates; for this, Naphthalin Emulsion is the ideal insecticide, as it is a violent poison to insects, and it remains on the plant for only 24 hours, evaporating completely: it is an insecticide that should be in every garden, as it is extremely effective for a short time and leaves no trace on the plant by next day. We have used this with great effect also on field crops but it is of too temporary a value on field crops, where its special merit of evaporating is not desired.

If neither Lead Chromate nor Naphthalin Emulsion is available,

Dry Paints.

dry metallic paints dusted on are effective deterrents in many cases and a first-rate deterrent is Bordeaux mixture, made from Copper sulphate and lime. Any insoluble copper salt is a good deterrent and if applied with care such is very effective. Contact Poisons are very neces-

Crude Oil Emulsion.

sary in a garden, and Crude Oil Emulsion is effective against nearly everything met with and can be made sufficient for every case. Used at $\frac{2}{3}$ pint in four gallons of water, it is an excellent insecticide against all forms of aphids, mealy bug, and soft sucking insect. Against some hard scales as against the larger harder sucking insects, one must use one pint in four gallons of water. It can be replaced to advantage

Vermisapon.

by Vermisapon, which is just as effective and which has also a stronger action against hard scales. Rosin Compound is equally useful in

Rosin Compound.

a garden and can replace Crude Oil Emulsion: it requires to be made on the spot, whereas Crude Oil Emulsion can be kept and mixed up as required.

Kerosene Emulsion is useful but is less effective and more costly than either of the above. If these insecticides are not available,

it is possible to use ordinary bar-soap, dissolving it in water at one pound in the gallon, but this is a more expensive insecticide, which is not always effective. Its effectiveness can be increased by adding Sanitary

Fluid or any crude form of phenyl such as is used for drains, etc., adding to four gallons of water, two pounds of soap, and $\frac{1}{4}$ pint of Sanitary Fluid.

In a garden, as in the compound of a house, one requires insecticides against other than simply insect pests on the plant. Ants are

a nuisance in many cases by making nests, by cherishing colonies of bugs, by making bushes untouchable owing to their bites. Against the red ant that nests in trees, one can only spray some strong insecticide, cutting off as many of the leaf nests as possible and directing the spray into each. We have eradicated red tree ants by this method. For ground-nesting ants one must find the nest and either pour in hot

water, Crude Oil Emulsion or Kerosene, or else dig the nest out. Against crickets, only two courses are possible; to flood them out if the water is available; if not, to spray every green thing near them with Lead Chromate heavily, as they are vegetarians and come out to feed

at night. Against Surface Caterpillars, those caterpillars which live in the soil and come out at night to cut down young plants, a bait made of bhusa or bran, sugar and white arsenic or lead chromate is the best remedy. (Formula No. 8.) One finds sometimes that plants

have been eaten out under soil level by what appear to be white ants. These are often a red ant (*Dorylus labiatus*) which works in the soil and behaves much as a white ant does.

One can meet this and ordinary white ant attack best by watering the attacked plants with weak Crude Oil Emulsion and water or by hanging in the water channel a cloth containing solid Crude Oil Emulsion, so that it slowly mixes with and "flavours" the irrigation water. Three gallons of Crude Oil Emulsion applied in this way per acre check the attack of white

ants upon vegetable crops and upon cane sets for instance; it is of course only a temporary cure, but it is effective for over a week and is usually sufficient to let the plants become well established. To

Cockchafers.

many foliage plants, the cockchafers that fly in the rains are a pest. One remedy is to put up a light over a barrel of water on which a little kerosene is placed; another is to thoroughly spray the plants with Lead

Cockchafer Grubs.

Chromate. Cockchafer Grubs are the white grubs found in flower beds, tubs and pots. They get there very often in the leaf-mould or manure applied by the *mali*; this will not occur if the leaf-mould is properly rotted and sifted before application; or they get there by the beetles laying eggs; in the latter case little can be done in a bed but to dig in raw leaf-mould and so provide food; in a pot or tub, the best cure is to repot, the best preventive is to use soapy bath-water for watering and not plain water, especially in the hot weather before the rains.

Soil Insecticides.

There are several insecticides widely advertised which are intended for application to the soil and are guaranteed to kill every wire worm, surface caterpillar, etc., usually by "generating poisonous gases." They cost as a rule over R30 per acre to apply. We have tested these and found a very efficient substitute by mixing phenyl, sanitary fluid or crude creosote with earth at 1 to 20 by volume and using that in the same way. Where white ants attack cuttings, roses, etc., or where ants attack vegetables at soil level, we have found this method extremely effective and comparatively cheap. No dressing of this sort has any effect in the rains but in the cold weather or in periods of light rain a thorough dressing of phenyled soil is a protection to plants that are attacked at or near the soil level. It is best to remove a little soil round the crown and put in phenyled soil: Crude Oil Emulsion can be used instead of phenyl or naphthalin. It was found that the patent insecticides sold under fancy names were not only excessively expensive but actually prevented the germination of seeds when applied at the strengths recommended by the makers. The ideal soil insecticide

combining efficiency and cheapness has not been found for India but the above are good for use in gardens.

Insecticides in the House.

In India, above all there are many household plagues which can be checked by a little care and the right insecticide. **Ants.** Ants are a constant nuisance; if they nest indoors, find the nest by tracing the ants to the nest and destroy it with a feather and some kerosene. If they are the big black ants which nest in masonry, stronger measures are required and one can only be guided by circumstances. An application of solid Crude Oil Emulsion to every entrance that can be found may induce them to move; if not, tar or cement must be used. A mixture of Tartar emetic, Sugar and water, in the proportion of 1, 10 and 100 respectively, put down in shallow dishes where the dog cannot lick it, poisons some ants and a small addition of Corrosive sublimate (a deadly poison) makes it more effective. Small ants are readily trapped by dipping an old sponge in weak syrup (a teaspoonful of sugar in a cup of water), wringing it nearly dry and putting it down; they cluster in the sponge, which is periodically taken up, dropped into hot water, squeezed out and again dipped in the syrup and put down. Pure Crude Oil Emulsion is an excellent thing to apply to the legs of store-room tables to keep off ants, and if a store room is washed periodically with Crude Oil Emulsion, instead of soap, ants will not come in (see also Ant Tape, Recipe 12). So also if ants come in through *chokuts* or nest there, a little kerosene should be applied. Crude Oil Emulsion should be used in every house, as the housekeeper's stand-by in all cases of ants and such like intruders which do not fly. So too

Bees and Wasps. against bees and wasps nesting; it is sometimes quite difficult to dislodge bees and

wasps' nests safely; a sprayer or a syringe and a tin of Crude Oil Emulsion (one pint in four gallons of water) are quite sufficient to dislodge bees and wasps that build combs on rafters or window-frames. For the ordinary wasp and bee that wants to build in a lock, a hook, a bicycle pump, or some similar cylindrical cavity, I recommend the device suggested by a correspondent and which is

described in his own words:—My bungalow seemed to be the rendezvous of all the bees, wasps and stinging flies of the station. Prominent amongst those creatures was one robed in a kind of metallic blue and with a figure like a hubble-bubble; this waspish lady would go round the bungalow daily and block up all the key-holes in my furniture; no matter how often I cleared these out, Mrs. Wasp would block them up again and put a white seal on them to let me know that it was she who did this. Things got so bad that I tried an experiment, which for the last twenty years has proved most successful. I simply cut a small block of wood, $8'' \times 4'' \times 3''$ and in this I bored 2 dozen holes $2\frac{1}{2}''$ deep by $\frac{1}{2}''$ dia. In each of these holes I put an empty Carter's Little Liver Pill bottle and hung the block of wood on a nail on the wall just in front of my writing table where I can see it. Result: for twenty years the key-holes of my furniture have never once been blocked. For twenty years, in spite of my being transferred from and to different stations, my 2 dozen bottles have had tenants; sometimes it is bees, sometimes wasps; they arrive, look over the establishment, select an empty compartment, stock it with provisions, which are sometimes small spiders, sometimes caterpillars, as the case may be, seal up the bottle and leave nature to do the rest.

In kucha-pukka or old brickwork, the large hornets sometimes make nests and go deep into the crevices.
Hornets in Walls. Such a nest should be checked at the very outset if possible; the queens are to be seen in the early hot weather seeking places to found nests and every such incipient nest should be destroyed. Once established, only very radical measures are of any use; tarring up all the exits and entrances is one method, as is plastering or cementing them; it must be done at night. If part of the nest is visible, it may be syringed with kerosene, but if so, the building may be uninhabitable for a day. Wasps' nests are vacated every cold weather, so that is the proper time to clear them away, cement or plaster up all cracks and make the brickwork unsuitable to them as an abode.

Borax is an insecticide that should be in every house; dusted down in corners it keeps off cockroaches;
Cockroaches. mixed with a little thick syrup and smeared on bits of tin, it is a deadly poison to cockroaches if put under

cupboards and in similar places where cockroaches dwell. Naphthalin is of course an essential against fish

Fish Insects.

insects, moths, woolly bear and the like.

A garment dusted with flake naphthalin can be safely packed and left with the conviction that nothing will attack it until, at least, all the naphthalin has evaporated; so for woollen garments exposed on shelves or in boxes.

Clothes Moth.

Occasional sunning and a liberal use of naphthalin preserves furs, woollen garments and the like with absolute certainty. So too for papers and pictures and the like which fish insects attack. There is no precaution but to use naphthalin, either dusting it on or, in the case of pictures, painting naphthalin emulsion on to the mount both outside and inside. A small quantity of naphthalin emulsion, stock solution, painted on to photos, pictures, etc., is the best way to apply naphthalin; they must of course be framed and glazed after, as naphthalin evaporates fairly rapidly.

For application to beds, clothing, etc., pure Pyrethrum powder

Fleas.

is the ideal insecticide, as it is completely harmless, clean and effective. Crude Oil

Emulsion is also invaluable against fleas and ticks in houses and on animals. If a house is flea-infested, wash the floors with Crude Oil Emulsion instead of soap. If an animal is infested with fleas or ticks, apply Crude Oil Emulsion: if a small animal, wash it in warm water, lathering on Crude Oil Emulsion instead of soap till the whole animal is covered: then, in a few minutes, wash the

Fleas on Dogs.

emulsion out and wash the dog with ordinary soap. If the dog is in a flea-infested house, then leave the emulsion on for twenty-four hours, as it prevents the dog picking up fleas. In the case of a larger animal such as a cow, apply Crude Oil Emulsion (one pint in a gallon of water) by means of a sprayer, a handful of grass or a broom. Crude Oil Emulsion injures no animal and is an excellent application to yoke-sores and other sores on cattle, as it heals them and also prevents flies settling on them. It is also not sufficiently generally known that coolies who apply Crude Oil Emulsion to their legs are not attacked by leeches and in a leech-infested country

Fowl-ticks.

this is a very useful method. Crude Oil Emulsion should not be applied to fowls.

but, if they have ticks, some sweet oil (*c.g.*, *til* oil) should be rubbed into the feathers where the ticks are. Another insecticide of which a bottle should be in a locked cupboard in every bungalow is Book Solution.

Book Solution, made of spirit, corrosive sublimate and carbolic acid. It is a deadly poison; with a long brush it should be painted on to the books and covers of books, as also inside the cover; no cockroach will then attack the book nor will fish insects or beetles harbour in it. One application is enough for a year in an open bookshelf, for longer if the books are in a closed one. For those who will not use a poison, we can only recommend naphthalin emulsion rubbed on, say, every three months.

One constantly sees advertised solutions for applying to wood-work, masonry, timber, etc., to prevent white ant attack. Such solutions are very

White Ant Solution.

easily made by boiling up white arsenic with washing soda till all the arsenic is dissolved. The solution is then diluted and applied. It is extremely poisonous and must be used with great care; if it is not procurable, Macdougall's Weed Killer, a powder sold in tins, is excellent and only requires dissolving in water. A substitute for it is ordinary blue-stone (Copper sulphate) and if white ants are coming up in a building, a liberal watering with this solution may do good. In buildings not used to live in, or in the open, arsenic solution may be used but it cannot be used indoors.

Many preparations are available for treating timber, posts, etc.; these are usually tar preparations of which wood-tar is better than coal-tar; these are painted on hot and while not absolutely preventives do keep off white ants for long periods.

Finally, there is one class of insecticide that the housewife should have and that is, for mosquitoes.

Mosquitoes.

This includes only a mosquito trap and a supply of citronella oil or some mosquito essence. The mosquito trap is on sale now and mosquito essences are no new thing. Mosquito oil (Recipe 11). Pure citronella oil is the best preventive of mosquitoes but is ineffective against Sandflies. A room or house may be temporarily rid of mosquitoes by putting a little pyrethrum powder on burning charcoal, or by lighting a little pile of the

powder and letting it smoulder. Mosquitoes are not killed but will go out if there is a convenient open window.

Spraying is the application in the form of a mist or spray of a liquid, so that the insecticide is evenly distributed on the plant or insects without waste. For this purpose spraying machines are sold varying in size and complexity from a simple syringe to a large pump worked by a petrol motor or a steam engine. For spraying on a large scale it is most economical to have a large motor equipment but such are not at present required in India.

A spraying machine ordinarily consists of a pump in a reservoir, a length of hose to direct the liquid, and a nozzle to form the spray. The reservoir may be separate, or attached to the pump; the pump should be without rubber parts and durable; the nozzle must break the liquid up into a really fine mist when sufficient pressure is applied to the liquid. For the present purpose there are three types of machine only required:—

- (1) The syringe, with a spraying nozzle (Fig. 1).
- (2) The "Bucket Pump" (Fig. 2), which is worked in a kerosene tin and is not fixed to any reservoir. It is the simplest and is suitable for gardens and houses, where only small areas are to be done.
- (3) The "Knapsack Pump" (Figs. 3 to 6), in which the same pump is fixed to a reservoir holding four gallons of water and which has straps for attaching it like a Knapsack to the shoulders; it should have two handles, one for working over the shoulder when it is used as a Knapsack, the other for using when the machine is placed on the ground for spraying trees. Such a Knapsack will do two acres of crop a day and spray fruit trees up to fifteen feet high, with a proper nozzle.
- (4) The "barrel pump" (Figs. 7 and 8) on wheels, with a more powerful pump and one or two lines of hose of larger size. This is used for crops or for fruit trees.

An important part of a machine is the nozzle. The Vermorel nozzle (Fig. 9) delivers a very fine spray in a cone and is automatic; the Bordeaux nozzle (Fig. 10) delivers a flat spray or a solid jet or any intermediate and requires adjusting. For only fine spraying on low crops, the Vermorel type of nozzle is suitable; for spraying fruit trees or anything tall, a Bordeaux type nozzle is almost indispensable unless one can lead the hose and nozzle up by means of a bamboo or pole. For general work we recommend the Bordeaux type nozzle, as it is extremely easy to adjust and does every type of work. We figure here the types of sprayers and nozzles we recommend. There are many patterns and makes which can be recommended, each having its own advantages but suitable for general work. There are a few points to remember in the upkeep of machines:—

Upkeep of Machines.

- (1) Use them at regular intervals, even if only to spray water, as this keeps them in good condition.
- (2) After spraying, always clean out the machine and pump clean water through to wash out the insecticides.
- (3) Leave plain water in barrels or wooden reservoirs to prevent shrinking and cracking.
- (4) Do not let rubber hose be bent at a sharp angle.
- (5) Always strain all water or insecticide as it is poured into the machine.
- (6) Kerosene attacks rubber, so wash it well out of the hose.

The choice of machine must depend on the work to be done and we cannot here advertise individual makers. We have described no machine which cannot be purchased in India, and we keep a list of all machines available, the agents and the prices. A spraying machine is of very great use in a garden or verandah for watering purposes and for spraying the foliage to clean the plants.

Equipment.

For the field—

- Knapsack Sprayers or Wheel Sprayers.
- Lead Chromate paste or powder.
- Crude Oil Emulsion or Vermisapon.

For the garden—

Syringe, Knapsack, Bucket or small Wheel Sprayers.
 Lead Chromate.
 Naphthalin Emulsion.
 Crude Oil Emulsion, Rosin and Soda or Vermisapon.
 Bordeaux Mixture.

For the fruit garden—

Barrel Sprayer on Wheels.
 Lead Chromate.
 Crude Oil Emulsion, Rosin and Soda or Vermisapon.

In the house—

A syringe or bucket sprayer.
 Crude Oil Emulsion or Vermisapon.
 Naphthalin Emulsion.
 Naphthalin.
 Boak solution.
 Kerosene.
 Borax.
 Citronella oil or Mosquito oil.
 Mosquito trap.
 Pyrethrum powder.

Recipes.*1. Lead chromate.*

Paste.— $1\frac{1}{2}$ lbs. in 30 to 60 gallons of water, or $\frac{3}{4}$ to $1\frac{1}{2}$ oz. in one kerosene tin of water.

Powder.—1 lb. in 30 to 60 gallons of water or $\frac{1}{2}$ to 1 oz. in one kerosene tin of water.

Home-made.—Dissolve 1 lb. of lead acetate or nitrate in the sprayer. Dissolve separately $\frac{1}{2}$ lb. of powdered potassium bichromate and put into the sprayer. For a kerosene tin or Knapsack sprayer, use $\frac{1}{2}$ oz. and $\frac{1}{4}$ oz. of the Lead Salt and bichromate respectively.

Keep well stirred and spray plants to be protected from insects.

2. *Naphthalin emulsion.*

Dissolve 6 oz. concentrated size (*Sirish*) in $\frac{1}{2}$ gallon of hot water, and add 1 lb. soft soap. Dissolve, in two gallons of kerosene, as much naphthalin as it will absorb; at ordinary temperatures about 2 lbs. 12 oz. is taken up; by warming carefully in the open over a small fire, 8 lbs. of naphthalin will dissolve. Add the naphthalin solution to the hot size-soap solution, add $\frac{1}{2}$ gallon of water and churn or agitate with a syringe or sprayer.

3. *Bordeaux mixture.*

1 lb. Copper Sulphate (blue-stone).

11 oz. Quicklime.

4 gallons water.

Dissolve the powdered blue-stone in water; separately slake the quicklime in water; mix the two, make up to 4 gallons and pour into the sprayer through the strainer. A knife blade put into the solution should not acquire a brown deposit of copper; if it does, add more lime.

4. *Crude oil emulsion.*

For a sprayer or kerosene tin, stir or rub up half a pint of Emulsion in water, pour through the strainer and fill up with water. The quickest way to mix is to pump water on the emulsion in a kerosene tin from the sprayer or to put it on the strainer and force it through by pumping a spray on it from the nozzle.

5. *Rosin compound.*

Powder 2 lbs. of rosin; boil a gallon of water with 1 lb. of washing soda crystals or 12 oz. of monohydrated soda. Add the powdered rosin to the boiling soda solution and continue boiling adding cold water at intervals as it boils up till the liquid comes quite clear and thin, like clear coffee. It will amount to about three gallons. For normal solution, pour 4 pints of this into the sprayer or a kerosene tin and fill up with water to 4 gallons; for strong solution add 6 or 7 pints.

6. *Sanitary Fluid.*

Under this name are classed all the forms of phenyl, crude Carbolic and Creosote emulsions used as disinfectants. They mix with water and are good contact poisons at a third to half a pint to 4 gallons of water. We recommend them chiefly as they are available in all bazaars.

7. *Soap.*

Common bar soap can be used if there is nothing else available. One pound to the gallon is the usual strength. For watering lawns 1 lb. to 15 gallons is used.

8. *Surface caterpillar bait.*

Dissolve a *chittack* of white arsenic and two *chittacks* of crude sugar (gur or jaggery) in two seers of water and mix thoroughly with $2\frac{1}{2}$ seers of *choka* (bran, not chopped straw). Put this down in small handfuls.

9. *Book solution.*

1 Pint Methylated Spirit.
 $\frac{1}{2}$ oz. Corrosive Sublimate.
 $\frac{1}{2}$ oz. Carbolic acid.

These are mixed and dissolved. Paint on with a brush; the liquid is poisonous and should not touch the fingers. Naphthalin emulsion is an imperfect substitute.

10. *White ant solution.*

1 oz. White arsenic.
 4 oz. Washing soda.
 1 quart water.

Boil till the arsenic dissolves. Make up to 4 gallons with water. Macdougall's Weed Killer is an excellent substitute.

11. *Mosquito oil.*

To equal parts of Kerosene and Coconut Oil add sufficient Citronella Oil to give the mixture a distinct smell of Citronella. A

few drops of Carbolic Acid may also be added (this is not necessary). This mixture is cheaper than pure Citronella Oil, is equally effective in repelling mosquitoes, does not irritate the skin and one application will last for 6-8 hours whereas Citronella evaporates in about half-an-hour.

12. *Ant tape.*

A solution of corrosive sublimate is prepared by heating the sublimate and water in a *porcelain* or *granite ware* vessel until the maximum amount is dissolved. This solution is allowed to cool, then filtered and ordinary cotton cloth or tape soaked in the filtrate for several hours, then removed and hung up to dry, after which it is ready for use. It is very important that no iron, tin or steel come in contact with the solution or the tape itself after being made. The tape or cloth is tacked or tied around legs of tables, along edges of shelves, etc., and ants will not cross it. It will thus successfully repel ants for some months before being renewed.

The following articles are stocked by chemists, etc.:—

Lead Chromate. 1 lb., 5 lbs.
Naphthalin Emulsion. 1 lb., 5-gallon drum.
Crude Oil Emulsion. 2 lbs., 5 gallons.
Book Solution. Pint bottles.
Pyrethrum Powder.

The following articles are generally procurable:—

Rosin.
Soda.
Sanitary Fluid or Phenyl.
Arsenic.
Citronella oil.
Copper Sulphate (Blue-stone).
Lime.
Borax.
Naphthalin.
Sweet oil.
Soap.

Notes on the Insecticides.

Lead Chromate is sold in paste ($1\frac{1}{2}$ lbs.) or dry or as a very fine dry powder containing 33 per cent. or 50 per cent. Lead Chromate. It may be made as described and the ingredients are readily obtainable from chemists. It is solely a poison for caterpillars, beetles, grasshoppers and all other insects which eat green plants.

Naphthalin Emulsion is a temporary poison to caterpillars, grasshoppers, beetles and other insects eating plants. It is absolutely harmless unless the mixture is deliberately drunk. It is used for putting on to photograph and picture-mounts and to books to keep off fish insects. It can be used to destroy ants' nests in houses and is a very useful thing to have in the house. It can be made at home or bought ready-made.

Crude Oil Emulsion is the standard insecticide against all sucking insects, that is, insects which do not bite the leaves of plants but sit on them in crowds and suck the juice (Greenfly, Blackfly, Plant-lice, mealy bug, Scale insects, etc.). It is also a splendid thing for dogs, if used like soap, as it kills ticks, fleas and lice. It heals sore places on animals and prevents flies laying eggs there or irritating the sores. It is first-rate for keeping off ants, for destroying their nests, for washing floors of rooms infested with fleas or other insects. Slowly dissolved in irrigation water, it checks white ants or other ants. It is harmless, can be easily mixed with water, makes no oily mess and is an absolute necessity in every Indian house. It is sold at R6-4-0 per drum of five gallons or Re. 1 per 2-lb. tin.

Terminapon is an excellent all-round contact poison, requiring only to be mixed with cold water and used at the same strength as Crude Oil Emulsion, for which it is an excellent substitute.

Book solution is a deadly poison; a single application once a year to books is sufficient. Can be bought ready-made or can be made up by any chemist.

Pyrethrum powder is the basis of Keating's powder and more efficacious. It is the powdered flower-head of a plant like a chrysanthemum and contains an oil that insects dislike. It is the only clean thing to apply to beds or furniture infested with bugs, as in dak-bungalows; the smoke from the smouldering powder drives out mosquitoes. The pure dry powder can be bought from chemists.

Rosin.—Common fir-tree rosin is required. It costs about three annas a pound retail; two annas wholesale.

Soda.—Ordinary washing soda is procurable everywhere. If much is to be used it is best to buy "monohydrated soda" costing $1\frac{1}{2}$ annas a pound in small quantities, seven rupees a cwt.

Sanitary Fluid is a mixture of Crude Creosote and rosin soap; it should mix with water to an emulsion or milky fluid. There are many brands of crude phenyls, disinfecting fluid, etc., all of which are suitable if they mix with water. They are not so safe to use on delicate plants as Crude Oil Emulsion.

Arsenic.—White arsenic (*Sambul*) is meant. It is a deadly poison. It is commonly procurable.

Citronella oil is obtainable from chemists and forms the basis of most mosquito lotions. We believe a little pure oil is cheaper and better than a mosquito lotion, which may not contain citronella at all and may become very wearisome if used often.

Copper Sulphate is the common blue-stone (*tutia*) procurable in all bazaars.

Sprayers.—All types, from syringes with spraying nozzles at R8, bucket sprayers at R15, Knapsack sprayers at R35 to large barrel machines for fruit trees at R100 are obtainable in India and we maintain a list of the patterns and agents which we keep up-to-date as far as possible. It is impossible to list these here and we can only advise those who require them to write for the pattern we recommend and the agent's address, specifying exactly what the sprayer is for. When sprayers are more extensively used, agents will be able to advertise; at present the demand is too small to make advertisement possible.

Mosquito Trap.

Two forms are figured, one the original pattern, the other the pattern made by Mr. E. F. Watson of Arthur Butler & Co., Mozafferpore (Fig. 11). The instructions for working the latter are as follows:—

"Place box (with lid held open by catch A) close to where mosquitoes collect during the day and as high up as practicable.

Dust out the bookshelves, hangings, etc., in room.

The mosquitoes thus disturbed will take refuge in the bottom of the open box. By touching the catch the lid will fall and the insects be imprisoned.

A teaspoonful or so of common petrol should then be poured in through hole B in the top of box. This can best be done by letting the petrol dribble slowly through a loose cork.

In five minutes the vapour will have taken effect and the stupefied insects may be shaken out through opening C in lower corner and the trap reset. The bodies should be burnt or otherwise destroyed. The best times for making catches are an hour after sunrise and at midday.

If mosquitoes are very bad in the neighbourhood, they should be kept out of the house as far as possible by shutting all doors and windows from half an hour before till half an hour after sunrise."

The former is worked in a similar manner, only the door is simply banged to and secured, instead of being closed by the release of the catch. Both boxes are of plain wood *lined with dark cloth* and may be of any reasonable size.

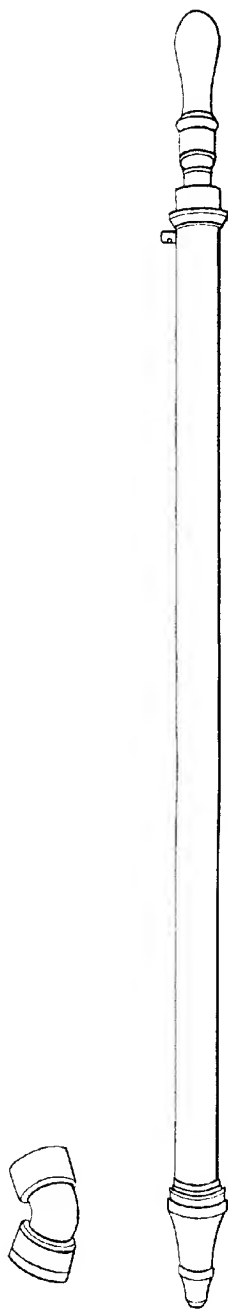


Photo-Engraved & printed at the offices of the Survey of India, Calcutta, 1911.

Fig. 1.—A syringe, with elbow detached.

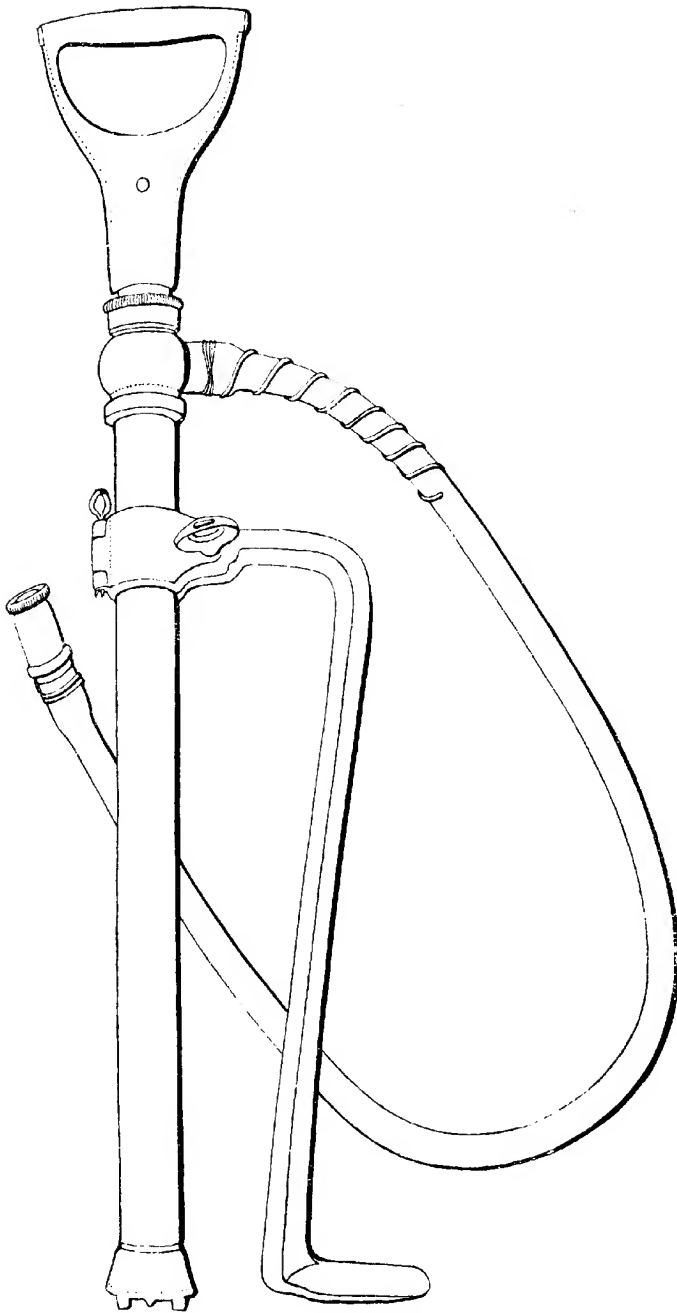


Photo. "Sadana" & printed at the offices of the Survey of India, Calcutta, 1911.

Fig. 2.—A bucket pump.

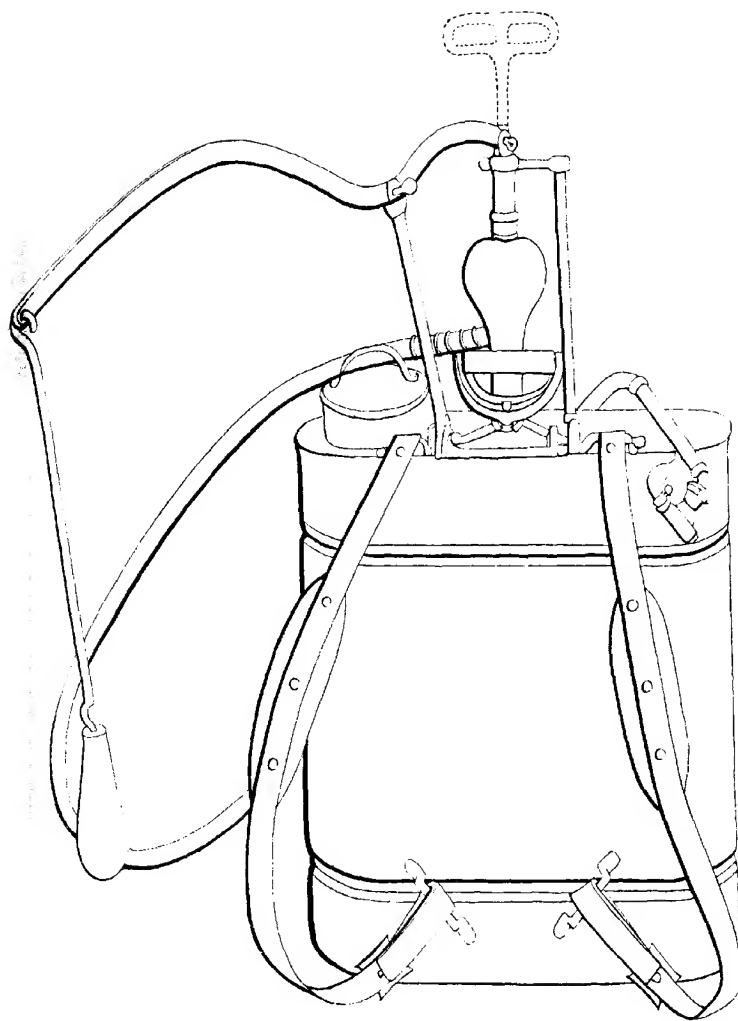


Plate. Referred to in the Office of the Survey of India. Calcutta. 1901.

Fig. 4.—Knapsack pump with enclosed pump.

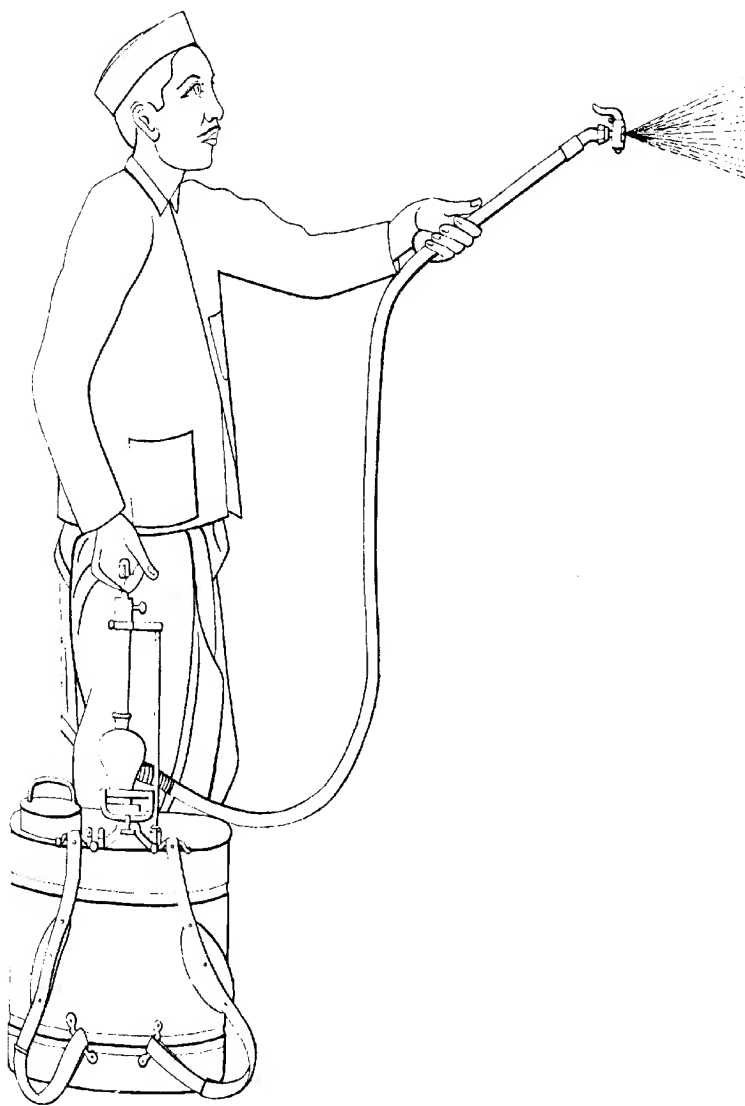


Fig. 5.—Pump used at the Forest Dept. Station, Calcutta, 1911.

Fig. 5.—A knapsack pump used on the ground for fruit trees, &c.



Photo Engraved & printed at the Office of the Survey of India, Calcutta, 1911

Fig. 6.—Knapsack pump in use.

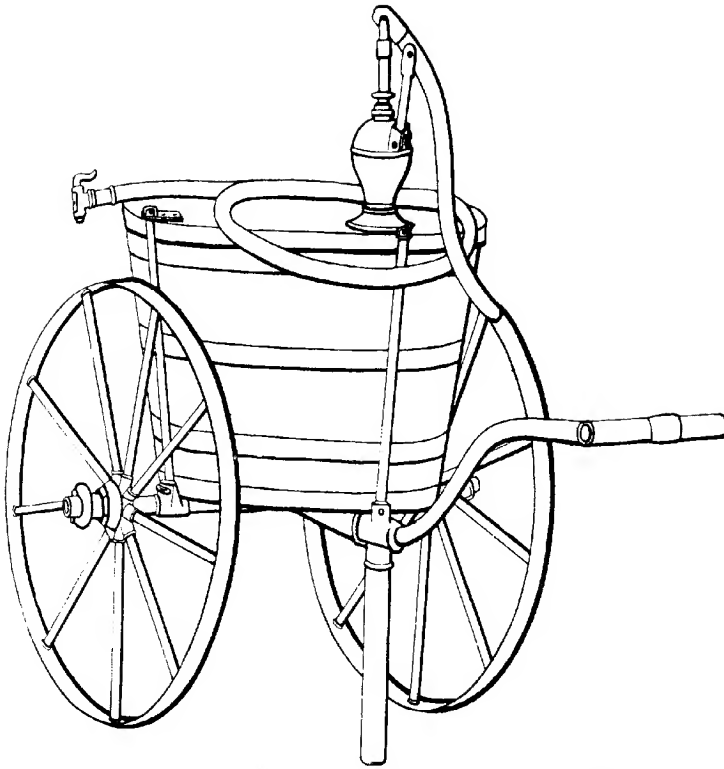


FIG. 7.—PUMP, AS SHOWN AT THE EXHIBITION OF THE SURVEY OF INDIA, CALCUTTA 1884.

Fig. 7.—A handy form of barrel pump.

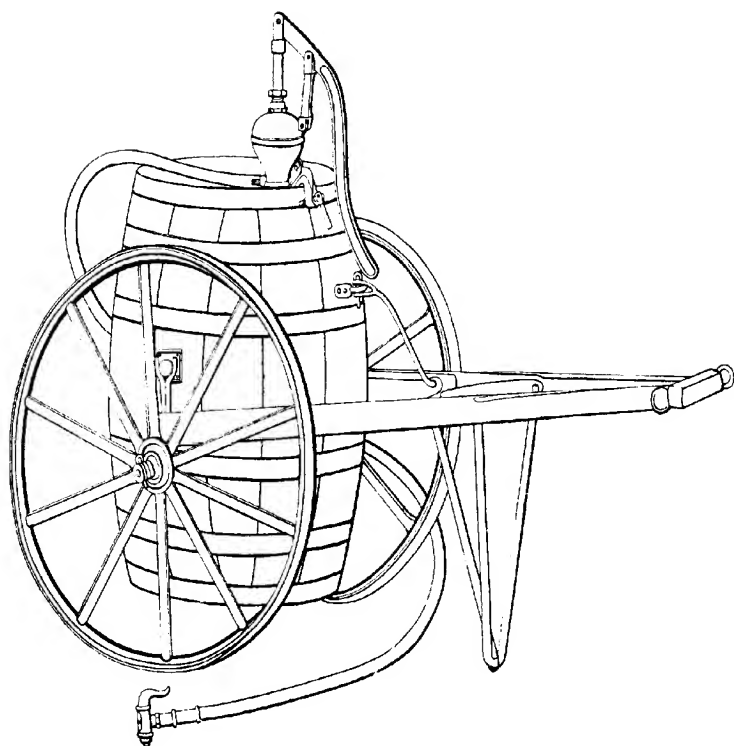
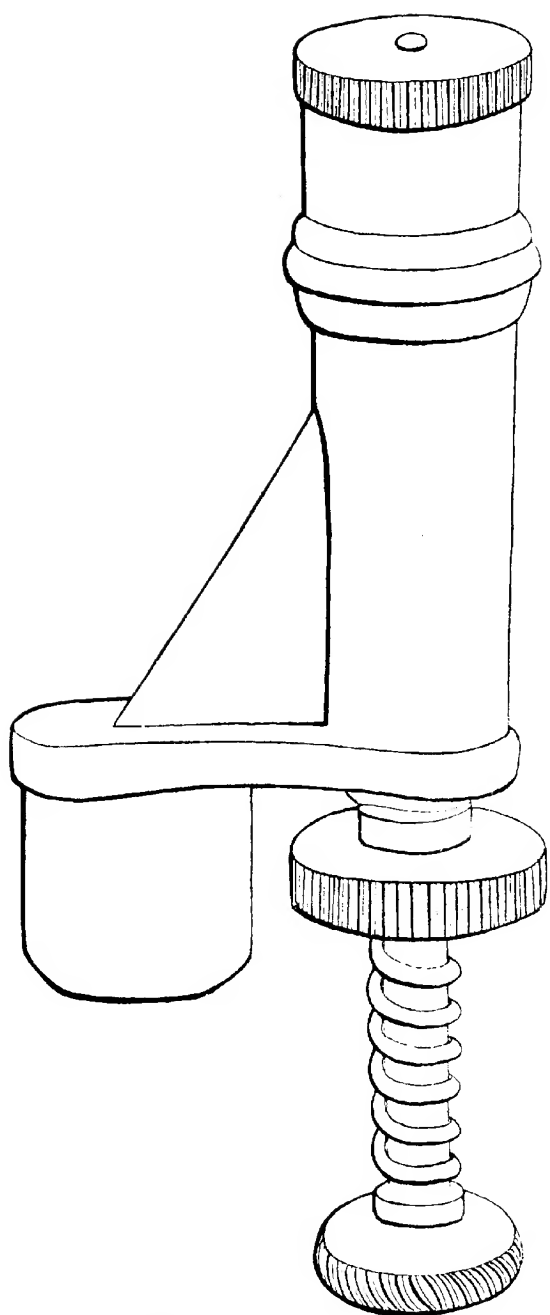


Photo. of machine in use at the station of the Survey of India, Calcutta, 1891.

Fig. 8.—Barrel pump and detachable cart.



From *Proceedings* printed at the Press of the Survey of India, Calcutta, 1891.

Fig. 9.—Vermorel nozzle.

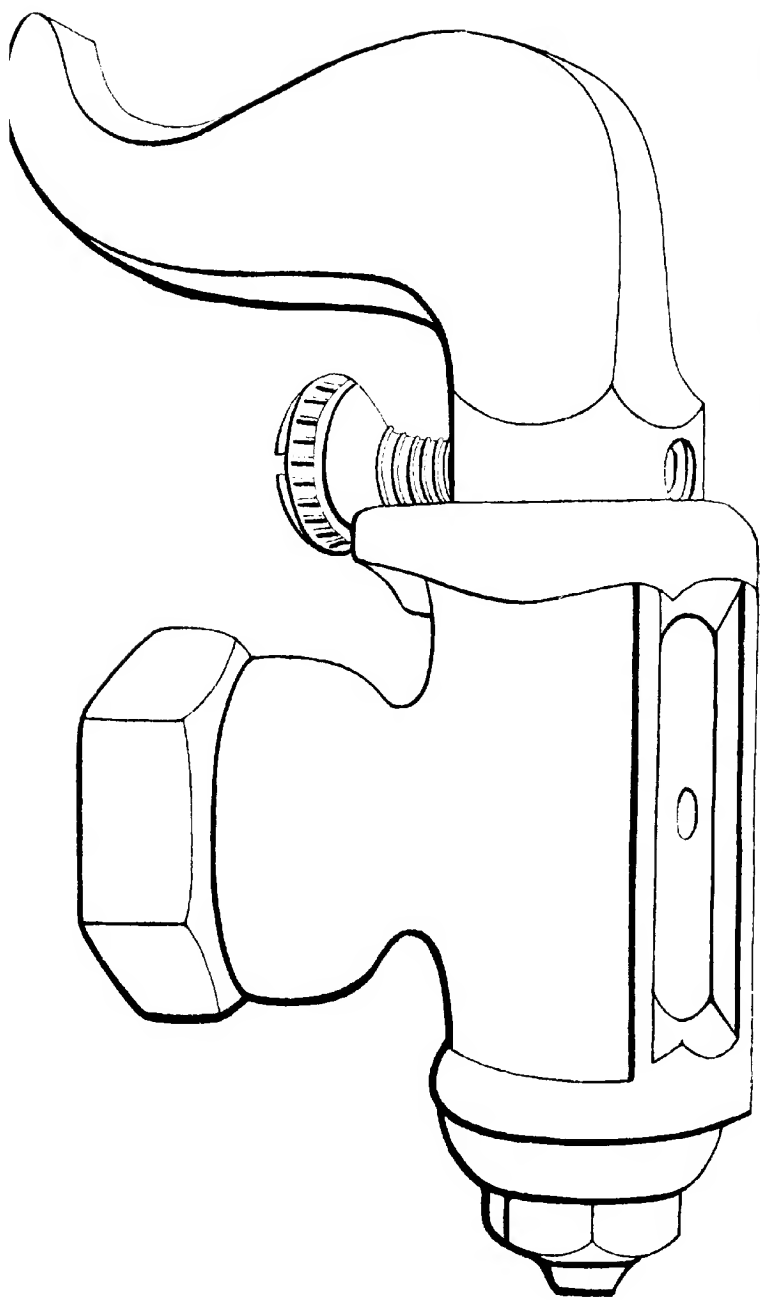
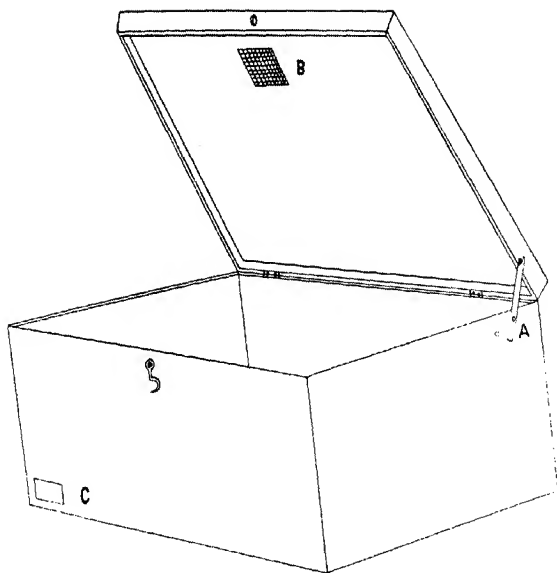
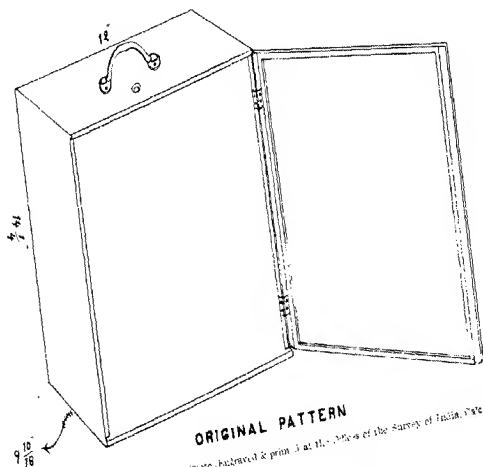


FIG. 10.—Bordeaux nozzle.

FIG. 10.—Bordeaux nozzle.



WATSON PATTERN



ORIGINAL PATTERN

Photo. Enlarged from a at the office of the Survey of India, Calcutta, 1911

Fig. 11.—The mosquito trap.

